EUROPEAN RESUSCITATION COUNCIL

[h1] European Resuscitation Council Guidelines 2025: Epidemiology in Resuscitation

Enrico Baldi 1,2 *‡, Jan Wnent 3,4,5‡, Maria Luce Caputo 6,7,8, Kirstie L Haywood 9, Gisela Lilja 10,11, Siobhan Masterson 12,13,14, Ziad Nehme 15,16, Gavin D Perkins 9,17,18, Fernando Rosell-Ortiz 19, Anneli Strömsöe 20,21,22, Ingvild B.M. Tjelmeland 23, Jan-Thorsten Graesner 3,4,5 for the ERC Epidemiology in Resuscitation Collaborators

1 - Division of Cardiology, Fondazione IRCCS Policlinico San Matteo, Pavia, Italy
2 - Cardiac Arrest and Resuscitation Research Team (RESTART), Fondazione IRCCS Policlinico San Matteo, Pavia, Italy
3 - Institute for Emergency Medicine, University Hospital Schleswig-Holstein, Kiel, Germany
4 - Department for Anaesthesiology and Intensive Medicine, University Hospital Schleswig-Holstein, Kiel, Germany
5 - German Resuscitation Registry, Nuernberg, Germany
6 - Department of Cardiology, Cardiocentro Ticino Institute, Ente Ospedaliero Cantonale, Lugano, Switzerland
7 - Fondazione Ticino Cuore, Lugano, Switzerland
8 - Faculty of Biomedical Sciences, Università della Svizzera Italiana, Lugano, Switzerland
9 - Warwick Medical School, University of Warwick, Coventry, United Kingdom
10 - Neurology, Department of Clinical Sciences Lund, Lund University, Lund, Sweden
11 - Neurology, Skåne University Hospital, Lund, Sweden
12 - Clinical Directorate, HSE National Ambulance Service, Dublin, Ireland
13 - Discipline of General Practice, University of Galway, Ireland
14 - School of Medicine, University College Cork, Ireland.
15- Centre for Research and Evaluation, Ambulance Victoria, Victoria, Australia
16 - School of Public Health and Preventive Medicine, Monash University, Victoria, Australia
17 - University Hospitals Birmingham, Birmingham, United Kingdom
18 - University Hospitals Coventry and Warwickshire, Coventry, United Kingdom
19 - Servicio de Emergencias Sanitarias 061, La Rioja, Spain
20 - School of Health and Welfare, Dalarna University, Falun, Sweden
21 - Centre for Clinical Research Dalarna, Uppsala University, Falun, Sweden
22 - Department of Prehospital Care, Region of Dalarna, Falun, Sweden
23- Division of Prehospital Services, Oslo University Hospital, Oslo, Norway

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BE-2845 Niel - Belgium
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∗ Corresponding author. Enrico Baldi; E-mail address: enrico.baldi@unipv.it

‡ joint first co-authorship

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[h1] Abstract

This European Resuscitation Council Guideline 2025 on epidemiology of resuscitation provides key information about incidence, patients' characteristics, system organisation and outcomes for both out-of-hospital and in-hospital cardiac arrest in Europe and beyond. Information regarding patients' post survival experience and causes of sudden cardiac arrest, including genetic factors, are also reported. Recommendations are provided to support the development of cardiac arrest registries, and improve OHCA follow-up with an emphasis on quality of life, and perform autopsy including genetic analysis in young individuals.

[h1] Keywords: Cardiac arrest, Epidemiology, Incidence of cardiac arrest, genetics, OHCA, IHCA, registries

[h1] List of abbreviations

AED: Automated External Defibrillator
COSCA: Core Outcome Set for Cardiac Arrest
CPC: Cerebral Performance Category
CPR: cardio-pulmonary resuscitation
EMS: emergency medical services
ERC: European Resuscitation Council
IHCA: in-hospital cardiac arrest
ILCOR: International Liaison Committee on Resuscitation
OHCA: out-of-hospital cardiac arrest
ROSC: Return of spontaneous circulation
VF: ventricular fibrillation

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[h1] Introduction

Sudden cardiac arrest is one of the leading causes of death worldwide. [1,2] Whether cardiac arrest occurs outside the hospital (i.e. out-of-hospital cardiac arrest – OHCA) or inside the hospital (in-hospital cardiac arrest – IHCA), differences in incidence and outcome have been reported over the years across countries. [3,4][EURECA THREE] These differences are due to several reasons, including variations in population characteristics (e.g. age, socio-economic status, co-morbidities), in system organisation (e.g. different emergency medical services (EMS) systems or differences in teams responding to IHCA; geographical variation; implementation of first responders network), and treatment provided by the system of care (e.g. quality of CPR, interventions, decisions on when initiate or terminate resuscitation, post-resuscitation care). [5] Differences also arise from variation in data collection practices (e.g. case definition, ascertainment methods and outcome verification).

For these reasons, since the early 1990s, the Utstein recommendations on outcome reports for OHCA and IHCA have been published and periodically updated to provide researchers with a single template to facilitate and harmonise data collection.[6-8] This enables inter-system and intra-system comparisons to identify gaps in knowledge, and to support clinical research.[7,8] Understanding the epidemiology of cardiac arrest as accurately as possible is a step towards understanding its causes, improving treatments and patients' outcomes.[9] This chapter provides an overview of incidence, patient characteristics, system organisation and outcomes of OHCA and IHCA. It also focuses on post-survival recovery and underlying causes of sudden cardiac arrest (SCA), including genetic factors.

The chapter focuses mainly on epidemiology in European countries; however, reference is also made to non-European countries. A section on epidemiology in lower resourced countries and remote areas is also included. Individual search strategies were constructed for each section of this guideline. Searches were conducted using PubMed, Embase and Cochrane. Only publications in English from the last 10 years were included, unless there was limited literature available or in the case of particularly relevant articles (i.e. articles with key information not included in subsequent studies). Abstracts were reviewed by at least two authors and relevant articles were read in full-text.

These guidelines were drafted, discussed and agreed upon by the European Resuscitation Council (ERC) Epidemiology in Resuscitation Writing Group and the ERC Guidelines 2025 Steering Committee. This Guideline was posted for public comment in EXACT DATE 2025. A total of [INSERT NUMBER] individuals from [INSERT COUNTRIES] submitted [INSERT NUMBER] comments, leading to [INSERT CHANGES] in the final version. Subsequently, the feedback was reviewed by the writing group, and the Guideline was then updated where relevant. The Guideline was presented to and approved by the ERC Board and the ERC General Assembly on xy June 2025. The methodology used for guideline development is presented in the Executive summary. [REF EXECUTIVE SUMMARY]

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[h1] Summary of facts on epidemiology in resuscitation

[h2] Out-of-hospital cardiac arrest

- The annual incidence of EMS-treated OHCAs in Europe is 55 per 100,000 inhabitants.
- The mean age of patients is of 67.2±17.3 years.
- Male subjects account for 65%.
- Seventy percent occur in private locations.
- A shockable rhythm is the initial presentation in 20% of cardiac arrests; 91% have a medical aetiology.
- Nine European countries have an OHCA-registry with full population coverage and 17 countries have a first responder system at least at a local level.
- The bystander CPR rate in Europe is 58% with significant regional variations (from 13% to 82%).
- The use of an AED before EMS arrival varies from 2.6% to 59% in different European countries.
- Survival after OHCA in in Europe is 7.5% with a range in European countries from 3.1% to 35%.

[h2] In-hospital cardiac arrest

- The annual incidence of IHCA in Europe is 1.5 to 2.8 per 1,000 hospital admissions.
- The proposed standard internal telephone number to alert the emergency team (2222) for IHCA in Europe is implemented only in 2% of countries.

[h2] Long term survival and return to societal participation

- In European countries where withdrawal of life sustaining treatment is practised, poor neurological outcomes occur in less than 10% of cardiac arrest survivors, whilst in situations where withdrawal of life sustaining treatment is not practised survival with poor neurological outcome is more common.
- The majority of OHCA survivors indicated the need for post-discharge follow-up with access to a multi-disciplinary team.
- One out of three OHCA survivors receive cardiac rehabilitation and only one out of ten receive brain injury rehabilitation.

[h2] Genetic variants and autopsy in cardiac arrest patients

- A clinically actionable pathogenic or likely pathogenic variant in a gene potentially related to the cause of sudden cardiac arrest is identified in up to 25% of OHCA cases younger than 50 years.
- Autopsy in young sudden cardiac arrest victims is currently not routinely performed in many European countries.

[h2] Low resource settings and remote areas

- The rate of bystander CPR and AED use is lower in low resource settings.

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- Lower resourced countries tend to lack OHCA registries adapted to the Utstein template and based on a reference territory
- Early BLS and rapid response by an EMS is crucial and determines the prognosis of an OHCA patient also in remote areas.

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[h1] Key messages about Epidemiology in Resuscitation

[h2] Out-of-hospital cardiac arrest

- European countries should implement national population-based OHCA registries that adhere to the Utstein template to monitor incidence, treatment and outcomes
- Data from registries should inform health care system planning and response to cardiac arrest.

[h2] In-hospital cardiac arrest

- Health care systems should implement IHCA registries adhering to the Utstein template.
- The standard in-hospital telephone number (2222) should be implemented for IHCA in Europe.
- There is a need for more research about IHCA in Europe.

[h2] Long term survival and return to societal participation

- Patients reported outcomes including physical and non-physical limitations should be measured routinely for all cardiac arrest survivors.
- There is a need for more research and greater provision of post-resuscitation rehabilitation services.

[h2] Genetic variants and autopsy in cardiac arrest patients

- A comprehensive autopsy, including genetic analysis, preferably using 5-10 mL of blood in EDTA, is recommended in all the victims of unexpected sudden death under 50 years old
- Autopsy results and genetic testing should be managed by multidisciplinary teams in specialised clinics ensuring the correct information and eventual screening of the first-degree relatives of the victims.

[h2] Low resource settings and remote areas

- Registries to measure epidemiology should be developed in lower resourced countries to enable improvement of treatment and patient outcomes.
- The improvement of the response system and, as a crucial part of it, the response time to the event should be pursued also in remote areas, as it is essential in determining the outcome of the patients

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[h1] Evidence informed Guideline

[h1] Out-of-hospital cardiac arrest

[h2] Incidence

The incidence of OHCA has been reported in multiple studies including the three major EuReCa studies.[2,10] [EURECA-THREE] Across all EuReCa studies, the incidence of cardiac arrest per 100,000 inhabitants demonstrated significant inter-country variation. In the 2022 three-month EuReCa-3 study, the annualised incidence ranged from 31 to 243 per 100,000 inhabitants, with an overall average of 82 per 100,000. Similarly, the incidence of EMS-treated OHCAs varied significantly with an overall incidence of 55 per 100,000 (range from 17 per 100,000 to 104 per 100,000). (Figure 1) [EURECA-THREE] The mean incidence of cardiac arrest remained consistent throughout the 8 years of the EuReCa studies. (Table 1).[2,10]

Accurately estimating the true incidence of OHCA remains challenging because of reporting limitations—most notably, the restriction to cases treated by emergency medical services (EMS), which likely underestimates the overall burden of disease. The proportion of patients with cardiac arrest where no resuscitation was started may differ systematically because of cultural norms or religious beliefs, bystanders' willingness to start CPR and variations in how and when the EMS are alerted.[11] As highlighted by the EuReCa THREE study, only EMS-treated OHCAs are reported in many European countries, meaning the reasons for not initiating CPR are missing from a significant portion of the population [EURECA THREE]. Given that dispatch centres serve a gatekeeping role for ambulance services and that most use a standardised dispatch protocol,[12] it should be feasible in the future to systematically collect data on true incidence of cardiac arrest. This aligns with the recent Utstein update on data collection from dispatch centres.[7]

The number of reported OHCAs in Europe has increased in recent years when compared with one or two decades ago.[10,13][EURECA THREE] Whether these differences reflect an increased number of OHCAs or simply a more comprehensive reporting is unclear. It is unknown if this can be partly explained by improved case ascertainment methods and increased coverage by regional and national registries or by an increase in intervention initiated before EMS arrival.

European OHCA incidence appears consistent with non-European settings. EMS-treated OHCA rates range from 44–56 per 100,000 population in Australia, New Zealand, Singapore, and South Korea, to 62–76 in the United States, and up to 97–100 in Japan—illustrating a similar degree of international variation. [14,15][ILCOR THIRD REPORT]

The incidence of OHCA was impacted by the COVID-19 pandemic. During the early stages of the outbreak, regions severely affected by the virus, such as Northern Italy and the Paris region in France, reported an increase in OHCA incidence of up to 187% compared with the same period in the previous year.[16,17] Further

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analysis confirmed that OHCA incidence increased significantly in regions with high weekly COVID-19 incidence, returning to previous values after the end of the outbreak. [18,19]

[h2] Patients' characteristics and presenting rhythms

Patient characteristics,[20-23] event circumstances,[24-27] underlying aetiology and presenting rhythms significantly influence survival outcomes.[28] Therefore, differences in these characteristics across European countries must be considered to understand regional variation in outcomes and opportunities for improvement.

The mean age of EMS-treated OHCA was reported as 67.6±17.5 year. [2] (Figure 1) This aligns with findings from the third ILCOR report on OHCA, where the mean age of OHCA patients treated by EMS ranged from 62 to 76 years, across different countries.[ILCOR THIRD REPORT] These patterns mirror the mean age of the general population in Europe [29] with similar trend in the United States, Australia and New Zealand.[15,30] Global comparisons reveal wider variability, patients from the middle east and Asia tend to be younger with a mean age of 50 years in United Arab Emirates and 57 years in Thailand. Conversely older ages have been reported in Japan (75 years) and Taiwan (76 years). [31] Interestingly, the mean age of the OHCA patients in whom the resuscitation was not started was 71.5±17.4 years, higher than in patients in whom CPR was started. [2]

Sex distribution among OHCA patients is similar across Europe, with males representing about 65% of patients overall [2] (Figure 1), e.g. 68% in Norway and France, and just under 60%, in Italy. [15][ILCOR THIRD REPORT] This pattern is largely in line with international data, [30,32] although lower in some countries, e.g. 57% in Japan [15,31][ILCOR THIRD REPORT] and higher in others, e.g. 82.7% in the United Arab Emirates. [31]

Approximately one-third of OHCA cases in Europe are unwitnessed OHCA, ranging from 17.3% in France to 46% in Denmark. [15] (Figure 1) Bystanders represent the largest group of witnesses, ranging from 44% in Germany and Denmark to 69% in France. EMS personnel are present at the time of arrest less frequently, ranging from 8% in Ireland to 16% in Switzerland. [15] Outside Europe, unwitnessed OHCA exceed 50% in the United States, Canada, Japan, South Corea, Singapore, Taiwan and United Arab Emirates, [15,31][ILCOR THIRD REPORT] whilst EMS-witnessed events seem to be similar globally. [15,30,31]

In Europe, the majority (70%) of OHCAs occur in private residences such as the patient's home with reported rates ranging from 61.5% in Switzerland to 76.3% in Italy. [2] (Figure 1) The proportion of cardiac arrests which occurred in a private residence increased during the COVID-19 pandemic. [18,33] Around 10% of OHCAs occur in public places or in nursing homes, with fewer cases occurring in schools, sport facilities and workplaces. [15][ILCOR THIRD REPORT] These findings are consistent with data reported from United States, Australia and Japan, [14] although OHCAs in nursing homes are less common in some Asian countries (about 2-5%). [14,31][ILCOR THIRD REPORT]

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The initial rhythm of arrest is one of the most important prognostic factors for short- and long-term survival. (Figure 1) In Europe, approximately one in five patients with an EMS-attempted resuscitation experience a 'shockable rhythm' (ventricular fibrillation (VF) or pulseless ventricular tachycardia) as the first monitored rhythm of cardiac arrest. [2] However, the rate of first monitored shockable rhythms varies three-fold across European countries from 11.4% to 36.8%. This may partly explain regional differences in outcomes. [2] Similar variability has been reported In other continents, such as Asia (from 4.1% to 19.8% in different regional areas) and Australia (22.9%-44.0%). [30,31] Emerging data suggest that the proportion of first monitored shockable rhythms may be declining over time, giving rise to a higher proportion of OHCA with initial asystole and pulseless electrical activity. [34-38] For example, in Sweden, the proportion of OHCA with an initial shockable rhythm declined from 39.5% in 1990 to 17.4% in 2020, with a larger difference in women (35.9% in 1990 to 11.4% in 2020). [35] Similar findings have been reported in other regions. [36-38]

An important consideration is that the initial rhythm reported depends on the time interval between the cardiac arrest and the first rhythm analysis. Large population studies highlighted that the odds of a shockable first monitored rhythm declined with each additional minute of no-flow time as VF degenerates into a non-shockable rhythm, and that bystander CPR significantly mitigates the degradation of shockable rhythms over time. [39-41]

Arrest aetiology strongly correlates with the initial rhythm and patient age. Medical causes precipitated 91.1% of OHCA, while trauma, asphyxia, drug overdose, drowning and electrocution made up the remaining cases. [2] (Figure 1) The leading cause of medical-related OHCAs include underlying cardiac aetiologies. In Sweden, the proportion of cardiac arrests caused by heart disease have declined for both men and women, from 80.5% in 1990 to 58.7% in 2020, [35] with similar declines observed in other high resource countries. [38] The German Resuscitation Registry reported increasing OHCA of presumed cardiac aetiology between 2006 and 2020, but with values that have risen from just below to just over 60%. [36] Most OHCAs in adults ≥40 years are from cardiac cause.[35] Drug overdose and suicide represents the leading cause in young adults and adolescents, and this is an increasing trend in some parts of Europe (e.g. in Sweden). [42]

[h2] EMS organisation

A 2025 survey of EMS system characteristics gathered data from 27 European countries about EMS dispatch, on scene management, and coverage by cardiac arrest registries [12]. Compared with a previous survey in 2019,[43] there were changes in the countries reporting a median EMS response interval of less than ten minutes in urban areas. Austria, Cyprus, the Netherlands, Slovakia and Slovenia reported improvement, whilst Belgium,

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Italy, Luxembourg, Norway, Poland and Switzerland reported a deterioration. [12] Variation was noted in how response intervals are calculated according to start (e.g. starting of the call, ambulance alerting) and end points. Early recognition and early initiation of CPR is crucial to improve survival. [44] To achieve that, several first responder systems have been established. [45,46] Only 17 countries reported having established first responder system without changes over time. [12,43]

Several countries established a new OHCA registry or expanded an already existing OHCA registry in the last five years (Figure 2). [12,43] Currently, nine countries report having an OHCA registry with national coverage (Cyprus, Denmark, Greece, Hungary, Ireland, Luxembourg, Norway, Sweden, Switzerland). [12]

2A 2B

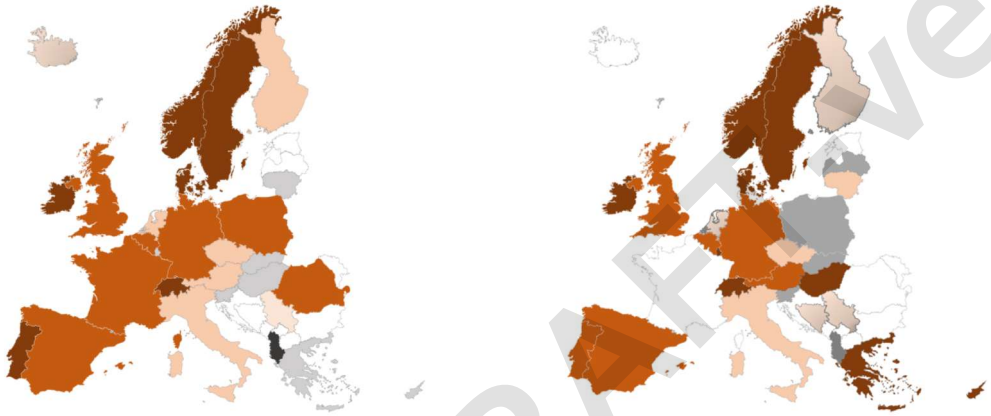

Figure 2.

Case ascertainment and data completeness are key drivers of how representative a registry is of the population it covers. [47,48] As can be seen in Figure 3, data completeness levels are high for EMS treatments and survival to hospital (> 80% data completeness). By contrast, data are less complete for hospital treatments. For health-related quality of life only one registry manages to capture information from more than 50% of the survivors (Norway). Healthcare systems need reliable and accurate information if they are to be used for quality improvement purposes.[7] This highlights that there is still much room for improvement across Europe. [12]

3A 3B 3C

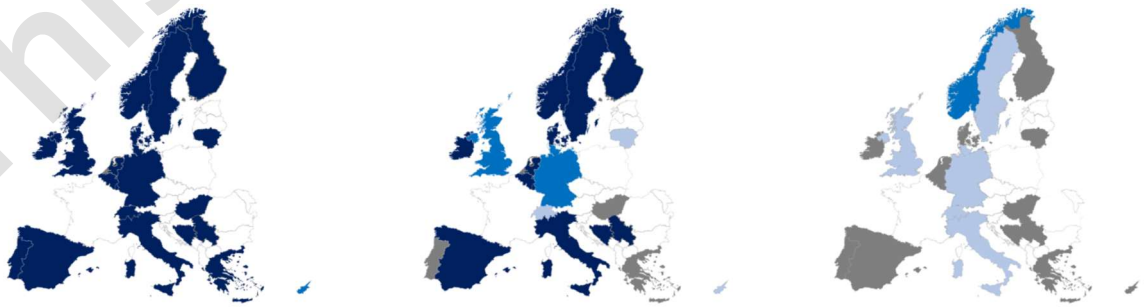

Figure 3.

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[h2] Community response

[h3] Dispatching community First Responders to cardiac arrest

A systematic review identified that eight mobile phone systems from seven countries in Europe are used to alert community first responders for OHCA.[45] This includes text messages or specially designed smartphone applications. Activation radii (i.e. the distance from the scene that first responders are activated), prioritising volunteers to reach the scene, exclusion criteria (e.g. unsafe environment, patient's age) and methods for retrieval of AEDs tend to vary between systems. A recent survey of EMS systems suggests there are more systems being used across Europe than have been published in recent literature. [43]

A meta-analysis on the impact of dispatching community first responders to cardiac arrest including six European countries, reported higher CPR and AED use with community first responders compared with the conventional emergency response. [46] The activation of community first responders also improved the rate of defibrillation before EMS arrival, particularly in private homes. [49]

Risks for dispatched community first responders are rarely reported. [50] In Denmark, the rate of injury was only 26/7,334 (0.35%), with one ankle fracture reported. [51] The psychological impact of a volunteer responding to cardiac arrest was also investigated; 24.7%, 5.5% and 1.2% of 5,395 respondents reported low, moderate, or severe impact, respectively. [52] More severe impact was associated with lack of CPR training, younger age and female sex. Dispatching first responders seems to be equally safe in both public and private locations. [53] Taking care in terms of psychological safety, continuing motivation and standardised debriefing needs to be included in first responder systems. [54]

[h3] Bystander CPR and defibrillation rates

Bystander CPR rates vary across Europe with a mean bystander CPR rate of 58%, but with a very wide range (13% to 82%). [2,55] (Figure 1) A common barrier to starting bystander CPR is a lack of knowledge (29.9%). In a survey, even among those who reported that they knew what to do during an OHCA and how an AED works, few were able to mention specific actions required. [56] A meta-analysis including 23 studies (10 from European countries) reported advanced age, lower socioeconomic and educational status, and marginalisation groups (due to race or language differences) were barriers to laypersons participating in resuscitation training. [57] Enablers identified were having previously witnessed a collapse, awareness of AEDs locations, certain occupations, and legal requirements for training. [57] The rate of bystander CPR appears to be influenced by the population awareness about OHCA. Community interventions such as 'Restart a Heart' may contribute to improved bystander CPR rates. [58]

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Database analyses suggests that bystanders are more likely to perform chest compression-only CPR than standard CPR, but with a wide variability across European countries. [13,59] Socioeconomic status affects the probability of receiving bystander CPR and socially deprived areas in a country have a lower probability of bystander CPR. [60] A review of 29 studies across 35 countries (including 9 studies from Europe) also reported higher rates of bystander CPR in countries with a higher Gross Domestic Product per capita. [61,62]
Unwitnessed OHCA at home and among older people are less often resuscitated by bystanders. [63] In contrast, in the case of exercise-related cardiac arrest, although representing a minority of all OHCAs, there is a much higher rate of bystander CPR reported than for other OHCAs (95% vs 77.4% in Denmark). [64] Similarly, bystander AED use was higher for exercise-related OHCA compared with the general OHCA population (38.3% vs 7.5% in a Danish population). [64]
The rate of AED use remains variable in European countries, ranging from 2.6% to 59% of cases, although an increase has been observed in some countries in the last decade. [65] (Figure 1) Bystander defibrillation is reported as less likely in urban settings, at home, and in women. [66]

[h3] Community Response during COVID-19 pandemic

According to a meta-analysis including approximately 50,000 OHCAs from around the world, the reduction in bystander CPR rate was directly related to the weekly COVID-19 incidence in each area. [18] Bystander CPR and bystander AED use rates fell during the COVID-19 period, particularly in public places, and particularly during the first COVID-19 wave in different European areas. [67,68] Community first responder engagement and bystander defibrillation rates did not differ significantly during lockdown and non-lockdown periods in two Danish regions. However, compression-only CPR was more often performed during the lockdown period then previously (79% versus 59%). [69] Similar findings were observed in a worldwide registry-based study that included data from several European countries [70,71] and in a large study in the UK. [72] There was a reduction in CPR initiated by first responders during the pandemic in Switzerland (45.3% during pandemic vs 62.2% before pandemic), but no difference in defibrillation rates by first responders (15.9% during pandemic vs 23.9% after pandemic), probably because alerting for community first responders was deactivated, but maintained for on-duty first responders. [73]

[h2] Outcome

The ERC recommends registries report outcomes according to the Utstein template to improve comparability between health systems. Registries should prioritise collecting information about survived event, ROSC, transport to hospital, survival and neurological outcome at discharge or at 30 days. [7]

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There is substantial international variation in survival rates and neurological outcomes. ILCOR reported survival to hospital discharge or 30-day survival ranged from 3.4% to 15.6%. [ILCOR THIRD REPORT] Some areas reporting even lower values (e.g. China 2.8%).[74,75] Unfortunately, resuscitation outcome is unknown in many countries particularly among those with developing emergency systems. [76,77]

Prognostic factors for cardiac arrest outcome are age, [20,21] gender, [78,79] aetiology, initial arrest rhythm, [24,80-82] previous and existing comorbidities, [83,84] location of the cardiac arrest, [85,86] whether the arrest was witnessed, [24,25] socioeconomic status, [87,88] and ethnicity. [89] Also the way health systems are organised, [90] available post-resuscitation care facilities (e.g. percutaneous coronary intervention, [91-94] temperature control, [93,95-97] cardiac arrest centres [98,99]) are contributing factors on the variability in patient survival. Furthermore, a significant variability in OHCA outcome may be observed in the same region or country, despite the same health system organisation, because of differences in demographics and the community response, [100-103] which can change over time. [104] Differences in decisions on when to terminate resuscitation in the field will influence the denominator, which will affect outcome rate. [105]

Unfortunately, these aspects are not always captured by current data collection systems. [106] However, despite their inaccuracies and limitations, data from registries constitute the standard for knowing the outcomes from OHCA. These registries should enable annual updates that describe trends in outcomes and compare different areas of the world. For example, in 2024 the US Cardiac Arrest Registry to Enhance Survival (CARES) documented a survival to hospital discharge rate of 10.2% for all EMS-treated non-traumatic adult OHCA cardiac arrests and 8.1% for survival with good neurological function. [1] The Australian Aus-ROC Epistry captures data from Australia and New Zealand and reported survival to hospital discharge/30-days as 13% with a range across different EMS from 9.9% to 20.7%. [30] The Swedish OHCA Registry has reported on the evolution in the treatment of OHCA during more than 30 years.[35]

In Europe, the European Registry of Cardiac Arrest (EuReCa) has performed 3-monthly cross-sectional studies including about 30 countries, providing the data source on OHCA for the Atlas of Cardiovascular Diseases in Europe. [107] Over the years of these studies the average survival has changed from 10.3% [range 1.1 - 30.8%] in 2014 to 8% [0%- 18%] in 2017, and 7.5% [3.1% - 35%] in 2022 [eureca 3 ref] (Figure 1). These results correlate well with annual reports from national registries. [108-114] (Table 2)

The Utstein comparator group (bystander witnessed OHCA with a first monitored shockable rhythm) represents the recommended subgroup for system comparison on survival. Reported survival rates are higher than the general population of OHCA patients: 20% in England, [108] 27.1% in Spain, [110] and 30% in Europe in 2022. [EURECATHREE REF] (Figure 1) Several European countries (Denmark, the Netherlands, Sweden, Czech Republic and Norway) exceeded 40% survival for this benchmark in 2022. [EURECATHREE REF]

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A peculiar sub-group of patients are those with a traumatic cardiac arrest, for whom resuscitation was considered futile in the past. [115] However, recent data suggest that a good outcome can also be achieved in these patients, as the reported good neurological status at discharge ranged between 2.0% in Germany [116] and 6.6% in Spain. [117]

During the first wave of the COVID-19 pandemic, the outcome of OHCA patients was worse regardless of known predictors of outcome and regardless of the incidence of COVID-19 in a region. [18] This highlights how the pandemic profoundly affected the management and survival of cardiac arrest patients worldwide. Scientific consensus [7] and policies from the European Parliament [118] have highlighted the importance of knowing local outcome data about OHCA in each country to issues guidance how to improve the response system and to enhance survival. The ERC recommends that maintenance of registries with high-quality data and adhering to the Utstein template should be an integrated part of each EMS service. This will help to improve their services and their patients' outcome.

[h3] Diversity, Equity, Equality & Inclusion (DEEI) discrepancies on outcome

Studies show that racial, gender, and socioeconomic disparities influence cardiac arrest outcomes. Women receive 27% less bystander CPR than men and survival is lower for women compared with men. [119-122] Black and Hispanic patients in the USA tend to have lower survival rates and to receive fewer interventions before EMS arrival. [123,124] Hispanic patients in the USA had poorer survival outcomes, even after accounting for medical history. [125,126] Lower-income and rural areas have longer EMS response times, fewer public AEDs and lower survival rates. [103,127-129] These disparities among these groups are reflected by their under-representation in resuscitation science. [119,130] Ethnicity, gender, socioeconomic status, geographic location, sexual orientation, and disability are all characteristics that contribute to differences in healthcare outcomes. [131] Equitable resuscitation science requires mitigating barriers that contribute to survival rates, training accessibility, and clinical decision-making. This includes ensuring diverse representation among authors and researchers who can then create culturally competent approaches to guideline development.

[h2] Epidemiology of paediatric resuscitation

Resuscitation in children is rare and most challenging presentation in OHCA. Most of the data on paediatric OHCA comes from North America and Asia. [132] While age-definitions and eligibility criteria differ across reports, data from Italy, Spain, Sweden, Norway, Germany, Denmark and the Netherlands indicates that the incidence of EMS-treated paediatric OHCA varies between 3.1 and 9.0 cases per 100,000 person-years. [133-139] The incidence of paediatric OHCA has a U-shaped relationship with age, with the highest incidence observed in

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infancy and adolescence. [133,135,136,138] The aetiology of OHCA also correlates with age: sudden infant death syndrome (SIDS) is the leading cause of death in children under 12 months of age, while hypoxia, trauma and cardiac causes are more prevalent in adolescent children. [42,134,136,139,140] Recent data from Sweden indicate that overdose and suicide are common in adolescent children and may be increasing. [42] The vast majority of cases, particularly in young children, are unwitnessed, occur in the home and have an initial non-shockable rhythm. [134-137,141] In adolescents, initial shockable rhythms are common and a third of all events are precipitated by physical activity. [138] Bystander CPR occurs in 41% to 88% of cases, although the provision of defibrillation before EMS arrival remains infrequent (<10%). [134-136,138,141,142] Rates of survival and neurologically favourable survival are low in paediatric OHCA, but these outcomes may also be influenced by age, aetiology and initial rhythm. [135,137,140] Overall survival to hospital discharge or 30-day survival varies between 7% and 40%, while neurologically favourable survival varies between 4% and 15%. [135,136,138,139,141,142]

Treatment by bystanders using public access defibrillation can result in survival rates exceeding 80%. [135] Data from Sweden and Netherlands also indicates that both short-term survival outcomes and neurologically favourable survival are increasing over time. [42,137,142] Despite limited reports from Europe examining the long-term quality-of-life and functional recovery of children survivors of OHCA, the available data suggests survivors maintain good neurological outcomes at longer-term follow-up. [139,143]

Although synthesised data on the incidence and outcomes of paediatric OHCA are lacking, existing reports indicate some differences and similarities across regions. In Australia, the incidence of EMS-treated paediatric OHCA was 4.9 cases per 100,000 person-years (6.7 per 100,000 in EMS-treated cases) and 8.1% of patients survived to hospital discharge. [144] In North American regions contributing to the Resuscitation Outcomes Consortium, the incidence of EMS-treated paediatric cases was 6.8 cases per 100,000 person-years (8.3 per 100,000 in EMS attended cases) with 10.2% surviving to hospital discharge. [145] In comparison, Asian regions contributing to the Pan Asian Resuscitation Outcomes Study reported a pooled survival to hospital discharge rate of 8.6%, although the incidence was not reported. [146] A recent systematic review exploring the influence of sociodemographic factors on paediatric OHCA indicates that the incidence of paediatric OHCA and the presence of bystander CPR were strongly associated with race and ethnicity, with minority populations being disproportionately impacted. [147] These factors may contribute to global differences in the outcome of paediatric OHCA.

[h1] In-hospital cardiac arrest (IHCA)

[h2] Incidence

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There is wide variation in the incidence of treated IHCA in Europe. [148,149] The ERC continues to recommend the adoption across Europe of the Utstein recommendations for reporting in-hospital cardiac arrest.[8] The Utstein recommendations advocate reporting incidence as the number of treated in-hospital cardiac arrests per 1,000 hospital admissions (excluding cardiac arrests which occur in the emergency department). A few studies on this topic have been published recently (Table 3 and Supplementary Table 1). [3,4,86,150-155] They confirm previous European studies, which showed an incidence of 1.5 to 2.8 per 1,000 admissions.[156-160] Patients are aged 67 to 75 years and most are male (60%-69%), which is very consistent across different studies and countries. [3,4,150-152,154,155] However, outcome data show significant variations between the different studies, also depending on differences in the denominator, but ranging between 27.3% and 62%. [3,4,86,150,154,155] (Table 3)

[h2] Response organization

The ERC was a key stakeholder in the development of the 10 steps toward improving IHCA quality of care and outcomes recommendations from ILCOR. [161] The programme highlights the importance of planning and preparation, systems to prevent IHCA and inappropriate resuscitation, optimal organisation of the emergency response to IHCA including delivery of guideline-based care and principles of person-centred culture (Figure 4).

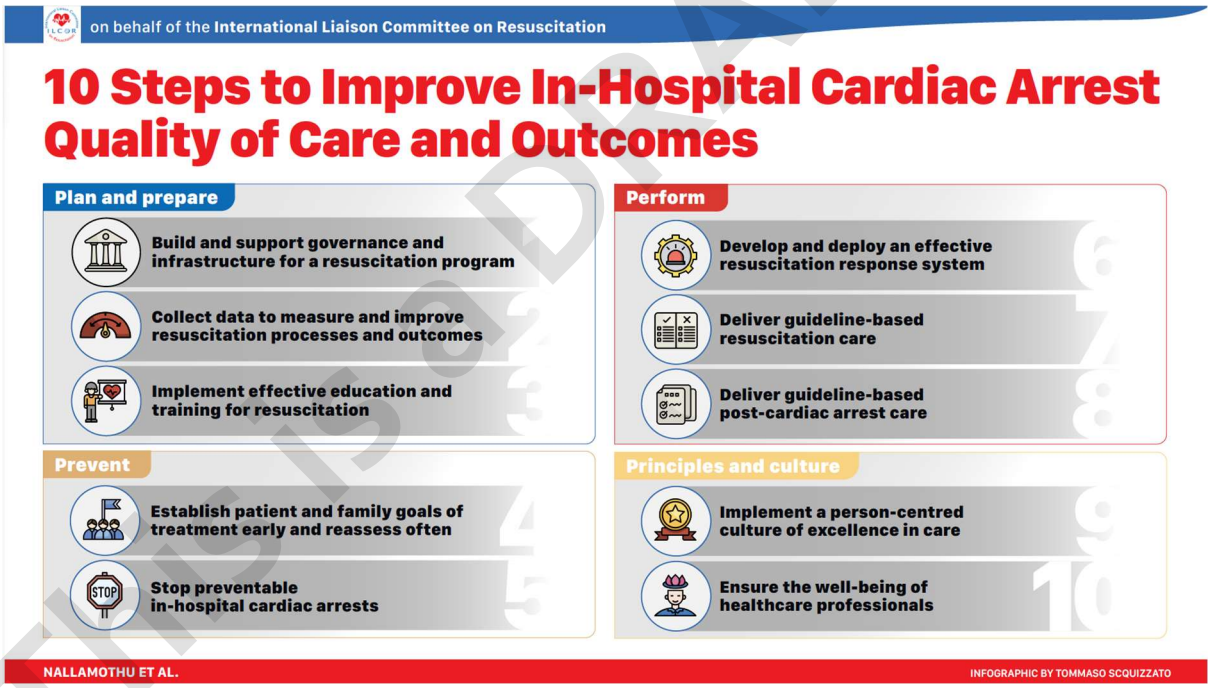

Figure 4.

[h3] Develop and deploy an effective resuscitation response system

Step 6 of the ILCOR initiative on improving IHCA describes the importance of a hospital-wide resuscitation response system that is easily and rapidly activated. It highlights the importance of a high-quality resuscitation team that includes preassigned, experienced, and interdisciplinary health care professionals. [161] A survey

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amongst guideline writing group authors (n=14, 100% response) covering 14 countries (Austria, Croatia, Denmark, France, Germany, Greece, Italy, Netherlands, Norway, Serbia, Spain, Sweden, Switzerland, United Kingdom) explored the characteristics of the response to IHCA. Most countries used a designated cardiac arrest team (78%). Team roles were pre-assigned before cardiac arrest in nine countries (60%), at the time of the cardiac arrest in two (20%), and there was no consistent approach in two (20%). The use of multi-professional teams was almost universal (93%) – just one country included physicians only. Some form of standardised advanced life support training was provided in all but one country. The ERC Advanced Life Support Course was used in 6 countries (40%), local advanced life support courses in 6 countries (40%) or no consistent approach in 2 countries (13%). Use of a defibrillator was permitted by physicians (all countries) and nurses in ten countries (73%).

The ERC continues to recommend the use of a standard internal telephone number (2222) for IHCA in Europe.[162] Despite these recommendations being made in 2016, penetration across Europe is limited. (Table 4) Forward citation tracking of the publications recommending implementation of 2222 as the standard number to alert the in-hospital resuscitation team demonstrates variable penetration across Europe. [163-166]

[h2] Outcome

Outcome data should be reported consistently to enable comparisons. Core outcome data should include reasons for CPR termination, ROSC, survival and neurological outcome at discharge and/or at 30-days. [8]

There are far fewer studies reporting outcomes from IHCA compared with those reporting outcomes from OHCA. Data identified by the ERC writing group are summarised in Table 3 and show that varying rates of ROSC (range 45%-72%), survival (range 27.3%-62%) and neurological outcome (range 16%-92%). There is also evidence that IHCAs in monitored areas, younger age, shockable rhythm, with less comorbidity are associated with best outcomes, [8] whilst IHCAs occurring early in the morning are associated with worse outcomes. [167] The ERC therefore strongly advocates for the roll out of IHCA registries in accordance with Utstein recommendations.

[h1] Long term survival and return to societal participation

[h2] Measurement of outcome and recovery

[h3] Long term survival and outcome

Severe hypoxic-ischaemic brain injury is a devastating outcome for cardiac arrest survivors. In most European countries where withdrawal of life sustaining treatment is routinely practiced, a poor neurological outcome is seen in less than 10% of cardiac arrest survivors. [168] In situations where withdrawal of life sustaining treatment

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is not applied, survivors with severe hypoxic-ischaemic brain injury are substantially more common. Even among survivors classified with a good outcome, the effects of hypoxic-ischaemic brain injury may impact everyday life. The most frequently reported neurological sequela is neurocognitive impairment, affecting most survivors in the early phase and up to 50% over the longer term, where it is mostly mild-to-moderate. [168,169] When assessed at group level, the use of generic measures of health-related quality-of-life suggests comparable levels of health with the general population. [169,170] However, more nuanced analyses reveal that several health-related quality-of-life sub-domains are poorer in cardiac arrest survivors, and that cognitive, physical, emotional problems and fatigue are common. [168,171-174]

Relatives of cardiac arrest patients (also known as 'co-survivors') are also at significant risk of emotional problems including anxiety, increased care-giver burden, and post-traumatic stress. [175-177] Being a witness to a relation's cardiac arrest increased the risk for emotional problems, [175] and cognitive impairment in the survivor was associated with increased caregiver strain. [177,178] Logistical and ethical challenges with collecting detailed information beyond hospital discharge remains a critical issue for long-term recovery reporting. [7,169]

A recent review of recovery and survivorship following paediatric cardiac arrest describes the commonality of cognitive impairment, including difficulties with memory, language, attention, communication, and executive functioning, impaired physical functioning, and activities of daily living. [179] Emotional problems, such as anxiety, depression, or behavioural problems, may manifest as somatic complaints or attention difficulties. Changes in family social functioning are also described. Few studies capture long-term outcomes beyond 2-3 years post hospital discharge. [179]

[h3] Registries

The Utstein template defines core and supplementary outcome variables and recoding methodologies to be collected in the event of OHCA. [7] Since its introduction, patient survival and neurological status have received increasing focus. Utstein guidance directs that neurological outcome is reported using the Cerebral Performance Category (CPC) and/or modified Rankin Scale (mRS) for adults and the Paediatric Cerebral Performance Category for children at hospital discharge or at 30 days. [7] Because the collection of post-discharge survival status and health-related quality-of-life data requires extensive resources they are identified as supplementary outcomes. Recommended health-related quality-of-life assessments are in line with the Core Outcome Set for Cardiac Arrest (COSCA) outcome reporting recommendations: that is, the Short-Form 36-item Health Status Survey (SF-36), EuroQoL EQ-5D-5L, or the Health Utility Index version 3 (HUI3) for adult survivors at 90-days [180] and the Pediatric Quality of Life Scale (PEdsQL) for children at 6-months. [181] However, a recent

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review of studies citing Utstein guidance found that the supplementary outcomes were rarely used, with fewer than 3.3% assessing health-related quality-of-life. [7]

[h3] Research

The introduction of the COSCA guidance has contributed to an improvement in outcome reporting: [182] 82% (45/55) of recent trials reported neurological function, of which 19 of 45 adopted the modified Rankin Scale as a measure of functional outcome; 33% (18/55) of trials reported health-related quality-of-life, with most (16 of 18) including recommended assessments. The EuroQoL EQ-5D-5L was most frequently used. However, continued heterogeneity in the reporting of health-related quality-of-life is hindering data synthesis. [170,173] Recognising the limitation of generic assessments, COSCA highlights the complementarity of domain-specific assessment, for example, of cognition, fatigue, anxiety, and participation. However, without specific assessment guidance, further heterogeneity in domain-based outcome reporting has been described. [171-174] For example, a review of 43 studies described more than 50 measures and a range of different cut-points used to assess neurocognitive function following OHCA. [171] Similarly, 16 different measures of anxiety or depression across 32 studies of cardiac arrest survivors were reported in another review. [174] Variation in measurement choice and cut points impacts prevalence reporting; standardisation is urgently required to support greater transparency in the assessment of symptom incidence.

Recent evidence suggests that the Montreal Cognitive Assessment (MoCA) is an acceptable measure of cognitive screening following cardiac arrest, [183,184] further underpinning recommendations for its use in this population. [185] The measure is usually administered face-to-face or via a digital meeting. Whilst a telephone version is available, the psychometric properties are less known, and hence this version should be applied with caution. [186]

Despite the Hospital Anxiety and Depression Scale (HADS) being widely used as a measure of anxiety and depression in cardiac arrest survivors, [174] there are few psychometric evaluations of its use with this population. [187] However, there is strong evidence supporting its use in the general population and in patients with cardiac disease. For example, evidence from a large Danish population of cardiac patients suggests acceptable evidence of essential measurement properties, in keeping with earlier studies. [188]

Fatigue assessment guidance following cardiac arrest is not available. Whilst the most widely used measures in cardiac arrest are the Fatigue Severity Scale (FSS) [189-191] and the Modified Fatigue Impact Scale (MFIS), [191-193] information of psychometric properties is limited in this population. Evidence from other patient groups (e.g. multiple sclerosis) suggest they are comparable when measuring physical aspects of fatigue in populations with mild to moderate fatigue. [194] However, where both physical and cognitive aspects are important, and where

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higher levels of fatigue might be anticipated, the somewhat longer Modified Fatigue Impact Scale is preferable. [194]

Guidance for the assessment of activities and participation following cardiac arrest does not exist. However, functional outcome scales and health-related quality-of-life assessments, such as the modified Rankin Scale and Short-Form 36-item Health Status Survey, commonly include these domains; the value of reporting health-related quality-of-life outcomes at a domain-level has been demonstrated. [195] Whilst overall physical and mental component summary scores on the Short-Form 36-item Health Status Survey suggested health status comparable to the general population, at the domain level impairment was substantial. This was particularly noted where people experienced difficulties engaging in roles related to work and other activities due to physical (50% impaired) and emotional (35%) limitations. [195]

Variation in outcome assessment following paediatric cardiac arrest (what is assessed, when, and by whom) is described, which may further contribute to the reported heterogeneity in post-arrest problems described and our understanding of long-term outcomes. [179] Moreover, the widespread use of blunt global assessments such as the Paediatric Cerebral Performance Category (PCPC) may inadequately capture change in patient and family important outcomes such as ability to engage with friends, school, and society. Introduction of the Paediatric-COSCA guidance in 2020 [181] is expected to contribute to improvements in outcome reporting and our understanding of the long-term recovery and survival of children. [179]

[h3] Routine practice

Measures to use during follow-up in clinical practice are detailed in the ERC Guidelines 2025 Post-resuscitation care, and includes guidance for screening of cognitive, emotional challenges, and fatigue and exploring limitations in physical activity and physical function. **[Nolan 2025]**

[h2] Rehabilitation and return to societal participation

[h3] Follow-up and screening

The 2021 ERC post-resuscitation guidelines recommended the assessment of physical and non-physical impairments both before and within 3-months of hospital discharge to identify rehabilitation needs and the provision of timely and targeted care through appropriate referrals [185]. An early follow-up assessment, including screening for cognitive and emotional challenges, is supported by an RCT from the Netherlands. [196-198] This cost-effective intervention contributed to a positive impact on mental health and an earlier return to work at one year. [198,199] Several European national guidelines and quality standards now recommend early follow-up following cardiac arrest – for example, Sweden, [200] France, [201] United Kingdom, [202] Scotland, [203] and the

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Netherlands. [204] To what extent cardiac arrest survivors in Europe are assessed before discharge and/or at follow-up is unknown.

Most cardiac arrest survivors who responded to a UK survey (95 of 123 (77%); median 2 yrs since cardiac arrest) reported being followed-up, typically by a cardiologist (62%). The majority (99%) indicated the need for post-discharge follow-up with access to a multi-disciplinary team; more than half (61%) preferring early follow-up within one month of discharge. Prioritised topics included: medical issues (as the cause of the cardiac arrest and heart disease), mental fatigue/sleep and screening for emotional and cognitive challenges. [205]

Almost all respondents to a survey of French ICUs reported providing oral information to cardiac arrest survivors prior to discharge (136/145, 94%). [201] However, just half noted the OHCA survivors' neurological and functional outcome in medical records or organized a post ICU follow-up which included cognitive and emotional screening. Described barriers to provision of follow-up appointments included: lack of awareness and knowledge; limited resources, including limited interdisciplinary collaboration; limited evidence to justify the cost; and an absence of practical recommendations. [201,204]

Informed by previous experiences [196-199] and European guidelines [206] the Essex Cardiothoracic centre started the UK's first dedicated follow-up clinic for cardiac arrest.[207] Cardiac arrest survivors (approximately 70 per year) are assessed by an ICU nurse and cardiologist before discharge and provided with multiple information sources, ranging from contact details to a peer support group. A post-discharge telephone call is organized within 48-hours, with follow-ups at 2-, 6- and 12-months for survivors and their carers. [207]

The 'Copenhagen Framework' [208] provides a further example of guideline translation [185,206] into clinical practice. A stepwise multidisciplinary approach to organise and manage follow-up and rehabilitation, implemented through two high-volume cardiac arrest centres (approximately 200 survivors a year), it includes: in-patient assessments; early follow-up 1-2 weeks post-discharge; and a more extensive follow-up at 2-months for both survivors and their family members.

[h3] Rehabilitation

The 2021 guidelines recommend that, where indicated, cardiac arrest survivors should be referred for specialist rehabilitation. [185] However, there remains a lack evidence for rehabilitation after cardiac arrest. [209] Current evidence based clinical practice recommendations for rehabilitation after cardiac arrest are discussed in the ERC Guidelines 2025 Post-resuscitation care. [Nolan 2025] Here we explore and describe available European rehabilitation pathways for cardiac arrest survivors. Participants in a large trial including mainly European OHCA survivors described their experience of rehabilitation within the first six-months post-arrest. [186] Just 29% out of 836 patients participated in cardiac rehabilitation, with fewer than 12% receiving brain injury rehabilitation (in-

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hospital: 12%; outpatient: 5%). [186] In a smaller Danish study of OHCA survivors who had been in employment before their arrest (n=38), 100% had a rehabilitation plan at time of discharge. [210] The most frequently accessed rehabilitation interventions involved psychologists addressing psychological issues (78%) and physiotherapists supporting exercise capacity (68%). Although rehabilitation participation was high, almost half of survivors reported unmet rehabilitation needs at 6-months, including support for existential issues, speech problems, return to work, fatigue and energy management. [210]

Whilst many cardiac arrest survivors are eligible for cardiac rehabilitation, engaging in these programmes alongside other patients who have experienced an acute cardiac/coronary event, those survivors whose cardiac arrest was idiopathic or due to non-ischaemic causes are generally excluded. [168,169,207] A survey of Danish cardiac rehabilitation facilities suggests that cardiac arrest survivors received less specialised cardiac rehabilitation than myocardial infarction patients. This included less patient education, exercise training, screening for anxiety and depression and nutritional counselling. [211]

Commencing at three-months post-arrest for survivors who had been discharged to home, a small Danish pilot study tested a combination of residential and home-based rehabilitation including education, physical activity training, and psychosocial support. [192] Carers were invited to attend the residential group sessions. Whilst this small pilot study is unable to provide sufficient evidence to support a change in practice, patient and clinician satisfaction was high. However, the specialised residential component may not be feasible in many settings.

Due to the prevalence of cognitive impairment in cardiac arrest survivors, a potential knowledge gap in care delivery by cardiology-based healthcare professionals has been described, [204,212] with a greater need for interdisciplinary collaboration proposed. [207,212,213] By example, a combined cardiac and cognitive rehabilitation programme is provided to cardiac arrest survivors at a single centre in the Netherlands. [214] More specifically, whilst those without cognitive impairment follow a traditional cardiac rehabilitation program, those with impairment participate in smaller cardiac rehabilitation groups with the addition of a cognitive rehabilitation programme. This pathway has not been evaluated, but 23% of cardiac arrest survivors referred for cardiac rehabilitation had cognitive problems. [215]

Brain injury rehabilitation is often provided to cardiac arrest survivors with severe hypoxic-ischaemic brain injury, with care provided alongside other patients with acquired brain injury – e.g., traumatic brain injury. [216] Whilst guidance on brain injury rehabilitation following cardiac arrest is not available in the European context, insight can be gained from several retrospective studies (e.g., patient records) from the last decade. A retrospective review of patients admitted to a Turkish brain injury in-patient rehabilitation facility between 2011 and 2015, reported anoxic brain injury following cardiac arrest in 5% of patients. [216] Patients with anoxic brain injury received the same intense rehabilitation program as patients with traumatic brain injury, including

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physiotherapy, occupational therapy, cognitive rehabilitation and speech-language therapy for 5 hours a day, for 20 days. In a small Dutch study of patients hospitalised and institutionalised because of unresponsive wakefulness syndrome (most due to cardiac arrest), more than half (54%) had not received any rehabilitation. [217] By contrast, a larger German study on 93 patients describes early, daily interdisciplinary neurological rehabilitation for patients with severe hypoxic-ischaemic brain injury (34% of cardiac causation), which continued until improvement ceased or complications were observed (including death). [218] Following a mean duration of 109 days, 41% were discharged to a nursing facility, 23% were referred for additional rehabilitation, 18% returned home, 10% needed further acute-care and 8% died. Of those comatose at admission, 82% remained comatose at discharge. A single French centre describes a six-month therapeutic intervention for institutionalised patients with anoxic brain injury (n=11/20 caused by cardiac arrest; mean 8-years post-event). [219] Consisting of medication, psychotherapy, support group, and physical, cultural and/or artistic therapeutic activities, it positively impacted quality of life and social participation.

[h1] Genetic variants and autopsy in cardiac arrest patients

The cause of cardiac arrest is known to be different according to the age of the victim. Coronary artery disease indeed represents the cause of cardiac arrest in most people over 50 years, but it explains only a minority of cases in young people. In young victims, most of the sudden cardiac deaths are attributable to other diseases, of which the majority are genetically determined structural or arrhythmogenic myocardial pathologies. [220,221] Differences in the cause of cardiac arrest become more pronounced at younger ages.[222,223] In young victims of sudden cardiac disease, the most common causes are hypertrophic cardiomyopathy—which is particularly prevalent in athletes—and arrhythmogenic cardiomyopathy. Other significant contributors include dilated cardiomyopathy and primary arrhythmogenic disorders, such as familial long-QT syndrome, catecholaminergic polymorphic ventricular tachycardia, and Brugada syndrome. [222,223] The identification of such an aetiology in the deceased may have important implications for families, allowing their arrhythmic risk to be defined and potentially preventing further sudden death events. In concordance with other European Societies the ERC recommends that a full post-mortem examination, including heart dissection, sampling for genetic and toxicological analysis, should be done in all the young sudden cardiac disease victims. However, although this recommendation is endorsed by numerous scientific societies in Europe and beyond, the post-mortem examination of young sudden cardiac disease victims is currently not routinely performed in many European countries. [224,225]

Genetic post-mortem analysis (so-called ‘molecular autopsy’) is important because about one third of the sudden cardiac disease remains unexplained after autopsy. [226-228] For this reason, the collection of 5-10 mL of

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blood in Ethylenediaminetetraacetic acid (EDTA) is recommended during post-mortem examination or whenever possible. [226,229] Modern techniques of DNA evaluation (e.g. multi-gene panels using next-generation sequencing) enable identification of a clinically actionable pathogenic or likely pathogenic variant in a gene potentially related to the cause of sudden cardiac death in up to 25% of cases, with significant implications for the care of their families.[222,230-237] Considering genetic data together with the phenotype provides much more informative data at a clinical level than using genetic data alone. Molecular and familial analysis together enable increased diagnostic yield. [238] The clinical data, including information about the deceased, the context and the triggers of the event, and the families, are all important.[239-241] Modern DNA analysis techniques enable the identification of a considerable percentage of variants of uncertain significance (VUS) on genes of interest. However, unlike pathogenic or likely pathogenic variants, these types of variants present significant challenges when explaining their significance to family members of the deceased and, if still alive, to the patients themselves. [240] The ERC recommends that genetic and clinical testing should be undertaken only by multidisciplinary teams including professionals with skills to counsel on the implications and the uncertainty of results and to decide about the appropriateness of extending the screening to the first-degree relatives of the victims, and experienced cardiologists able to direct testing to the correct phenotype.[242] These teams should ideally be based in tertiary centres that offer comprehensive professional expertise and can receive patient referrals from a wide region. These centres should also be capable of periodically reanalysing and reclassifying variants as new data on pathogenicity become available.[237,243] There has been consensus that the autopsy and genetic testing should be performed in those under the age of 40 years; [240,244] however, other studies suggest that the age range should be extended up to 50 years.[245] [227,241,246] This wider age range is supported by two recent expert consensus statements on genetic evaluation of patients with unexplained sudden cardiac arrest. [242,247] These statements represent the official views of the European Society of Cardiology (ESC) and numerous arrhythmia scientific societies worldwide (European Heart Rhythm Association, Heart Rhythm Society, Asia Pacific Heart Rhythm Society and Latin American Heart Rhythm Society). Therefore, the ERC strongly recommends performing a comprehensive post-mortem examination (including heart dissection and toxicological analysis) and a molecular autopsy on all victims of unexpected sudden death under 50 years old.

[h1] Low resource settings and remote areas

Out-of-hospital cardiac arrest and IHCA occur worldwide, regardless of a country's available resources, population density, or remoteness. Although responding to cardiac arrest may not be a primary focus of emergency services in lower-resourced countries, the fundamental principles of resuscitation still apply. However, the epidemiology, organisation of response and treatment, and both short- and long-term outcomes

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differ significantly in these settings and in remote areas. Therefore, it is important to consider the treatment of OHCA and IHCA in less-resourced countries and remote regions separately. The response to OHCA in remote areas of high-resourced countries involves entirely different strategies and resource allocation compared to those in lower-resourced settings.

[h2] Low resource settings

The only available data on OHCA in low-resourced countries in Europe concern Serbia and Bosnia and Herzegovina, [248,249] two of the most low-resourced countries in Europe, where an incidence of OHCA of 85.6 per 100,000 and 54 per 100,000 inhabitants/year respectively is reported, which aligns with the median reported incidence of 55 per 100,000 inhabitants/year in Europe. [EURECA THREE] Some characteristics of OHCAs in those countries are similar to other European countries, such as the majority of events occurring at home, but other aspects are significantly different. In particular, the rate of first monitored shockable rhythm reported in Bosnia and Herzegovina is consistently higher than in other European countries, representing 45.6% of OHCAs. [248,249] The rate of bystander CPR (15.3% among bystander witnessed in Serbia and 3.3% among all OHCAs in Bosnia and Herzegovina) and AED use (0% in Bosnia and Herzegovina) is lower compared with the European average value. [248,249] This reflects on the outcome, as the ROSC and survival rates in both countries are lower than the median value in Europe. [2] [EURECA THREE]

The differences between low– and high-resourced countries become even more apparent outside Europe, where there is a reporting bias because of a lack of OHCA registries adapted to the Utstein template and based on a reference territory, [250] both of which are essential for reliably understanding the phenomenon. Most reports are derived from hospital-based registries that do not follow the Utstein template, and often describe cases where patients in cardiac arrest are transported to the Emergency Department without EMS activation, [251-255] leading to clear delays in treatment, compromised care, and poorer outcomes.

Estimating the incidence of OHCA is only feasible in a few countries with functioning registries, such as South Africa and Argentina—both classified as ‘upper-middle income’ countries. Reported incidence rates are 23.2 per 100,000 inhabitants per year in Cape Town and 53 per 100,000 inhabitants per year in the city of Bariloche, although the latter figure includes all OHCAs, not just those treated by EMS. [256,257] No incidence data are available from other countries.

The available data suggest that the mean age of OHCA patients in low-resourced countries is lower than in high-resourced settings, ranging from 55 years in Pakistan[255] to 63 years in South Africa.[256] This likely reflects both a younger general population and differing attitudes toward resuscitation in elderly individuals. The location of

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OHCA, though difficult to interpret because of reporting limitations, varies considerably. The proportion of OHCAs occurring at home ranges from 56.1% in China[75] to 79.7% in South Africa.[256]

A first monitored shockable rhythm is found in only a small fraction of patients—approximately 1% in both Pakistan[253] and South Africa.[256] Bystander intervention is also rare, with CPR rates ranging from 2.3% in Pakistan and 5.1% in Iran, [253,258] to 18.7% in China and 22% in Vietnam,[75,259] underscoring the strong correlation between bystander CPR and gross domestic product.[61] Outcomes for OHCA patients in these settings are generally poor: in cohorts with presumed lower reporting bias, ROSC is about 1%,[256] and survival to hospital discharge ranges from 0% to 4%.[253,255,256,258] There are no data on IHCA in low-resourced countries in Europe. Existing data from non-European countries are limited and typically based on small patient cohorts. The reported incidence in Egypt is 1.77 per 1,000 patients discharged,[260] while the median age in Uganda is 40 years.[261] ROSC rates range from 49.3%[262] to 62.2%,[261] and survival rates from 14.9%[261] to 35.5%,[262] with improved outcomes reported following the implementation of in-hospital Rapid Response Teams. [260,263] In summary, for both OHCA and IHCA in low-resourced countries, the establishment of robust registries is of paramount importance to accurately define the epidemiology and to monitor progress in treatment and patient outcomes.

[h2] Remote areas

Regarding OHCAs in remote areas, available European data are limited to mountain regions, which represent the most remote settings within the European context. Studies from the French,[264] Polish,[265] and Austrian Alps[266] reveal some common features—such as a mean age of OHCA victims around 60 years and a predominance of male patients—but also highlight significant differences in bystander intervention and outcomes. French data suggest a key reason for this variation: OHCAs that occur on ski slopes are more likely to receive bystander CPR and AED use, leading to better survival rates, compared with those that occur off the slopes or in other mountain settings, including typical Utstein-defined locations such as homes, public spaces, or workplaces.[264] This emphasises that the response to the arrest, rather than the location itself, is the critical factor in determining patient outcomes. Remote areas are more widespread outside Europe, and informative data on OHCA in these contexts come from Canada,[267] the United States,[268] and Australia.[269,270] In these countries, OHCA patients in rural and remote settings tend to be younger, and bystander CPR and AED use are more common than in urban areas. However, significantly longer EMS response times in remote regions consistently reduce the likelihood of ROSC and survival in all three countries, underlining the particular challenges of managing OHCA in geographically isolated areas.

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[h1] Conflict of interest

EB is part of the Cardiac Arrest Registry of Lombardy Region (LombardiaCARe), member of the ILCOR Research & Registry Working Group, member of the SEC BLS of ERC. JW is member of the German Resuscitation Registry Steering Committee, of the German Society of Anaesthesiology and Intensive Care Medicine of the German Resuscitation, of the EuReCa working group and of the ERC Dashboard working group. SM is Emeritus member of the ILCOR BLS Working Group and Member of the EuReCa Study Management Team. ZN is supported by funding from the National Heart Foundation and the National Health and Medical Research Council. JTG is member of editorial board of Resuscitation journal, project leader of EuReCa and chair of the German Resuscitation Registry; he also received travel refunds from Weinmann:emergency and Laerdal foundation. GDP is an Editor for Resuscitation; Co-Director of the OHCAO Registry and Director of Science and Research for the ERC and President Resuscitation Council UK. MLC, KLH, GL, FRO, AS, IBMT reported no COI.

[h1] Figure legends

Figure 1. Infographic concerning the key points related to the epidemiology of out-of-hospital cardiac arrest

Figure 2. Coverage of OHCA registries in European countries in 2019 (2A) and in 2025 (2B). Dark orange is national registries covering the whole country, orange is national registries covering parts of the country. Light orange is several local registries and light orange with dark shadow is one local registry. Grey is no registry and black is unknown. Countries not participating are left white.

Figure 3. Availability of data in out-of-hospital cardiac arrest registries in Europe. Dark blue is availability for over 80 % of the cases, blue is availability of data from 50-80 % of cases and light blue is less than 50%. Grey means data is not collected. Figure 4A is ambulance data, figure 4B is hospital data and figure 4C is patient-reported quality of life data.

Figure 4. 10 Steps to Improve In-Hospital Cardiac Arrest Quality of Care and Outcomes.

[h1] Table legends

Table 1. The mean incidence of OHCAs in the three EuReCa surveys

Table 2. Outcome reported for OHCAs in different European countries

Table 3. IHCA incidence, characteristics and outcome in published studies from 2020 to 2024

Table 4. Summary of use of 2222 emergency call number for IHCA in European Countries.

Supplementary Table 1. Published (2020-2024) studies' compliance with the Utstein Core Elements[271] - reporting guidelines for in-hospital cardiac arrest (IHCA).

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